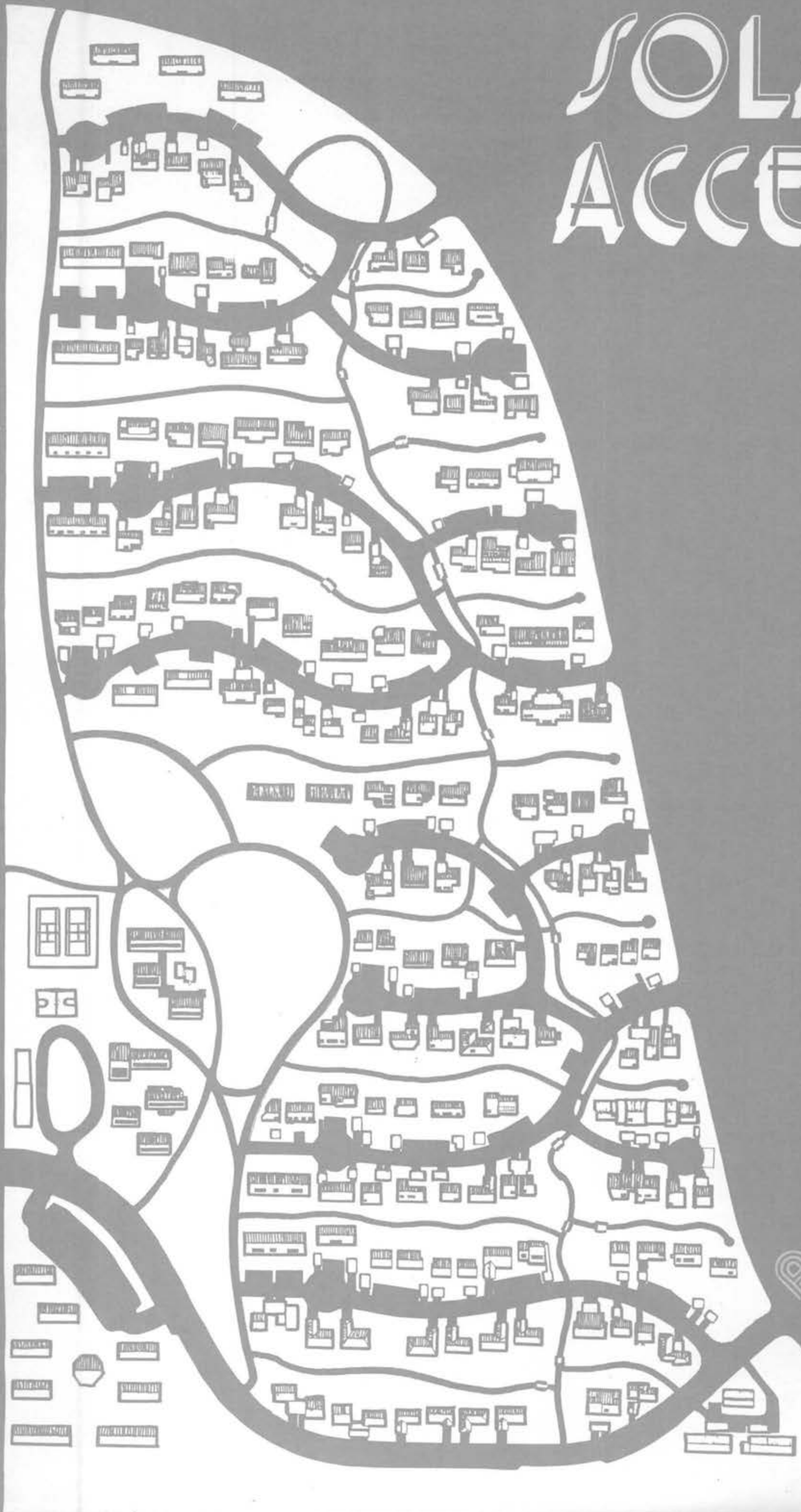
# SOLAR ACCESS



A LOCAL RESPONSIBILITY

CALIFORNIA ENERGY COMMISSION

DECEMBER 1978

# SOLAR ACCESS:

# A LOCAL RESPONSIBILITY

California Energy Commission

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## 1.0 INTRODUCTION

Interest and investment in solar systems for residential uses have skyrocketed in the last two years. What was once the realm of the lone wolf and solar pioneer is now becoming part of the mass market. California's 55 percent solar tax credit will add further impetus to the rapid transition to solar energy.

Yet one issue remains unresolved--protection of access to sunshine to enable these solar systems to continue to function in the years ahead. This complicated issue will not be resolved easily or rapidly, particularly in retrofit situations. Solar energy use for heating and cooling or electricity generation has many ramifications for the law, planning, and building. At this time, "solar rights" do not exist in California, but several bills now under consideration would help establish them. However, good protection of solar access can be accomplished using existing land use controls and design practices. Most of these involve primarily the developer and local government staff and their land use planning and building practices and requirements.

This report is an introduction to "Solar Access" for developers and local government officials who now bear the responsibility for promoting solar access. It includes:

- An introduction to the basic types of solar systems and requirements for sunshine.
- The principles of land use planning for solar access.
- A discussion of the current status of "solar rights" and the possibility of changes in the near future.
- A description of a solar subdivision in Davis, California, where many of the principles of solar access have been applied.

A glossary is included in Section 7.0 to help those unfamiliar with the terms used in this report.

## 2.0 AN INTRODUCTION TO SOLAR SYSTEMS

The energy from the sun and climate resources can heat and cool buildings and water, generate electricity, cook food, and drive pumps and other mechanical engines. In residential areas, the immediate primary uses are space heating and cooling and water heating.

There are two basic types of solar systems for these purposes. PASSIVE solar systems utilize energy from the sun and climate resources to heat and cool without the need for auxiliary energy for pumps or controls. In these space conditioning systems, the windows are the collectors and the elements of the building itself are used for storing the sun's energy for heating or for facilitating the use of the cool night breezes for cooling.

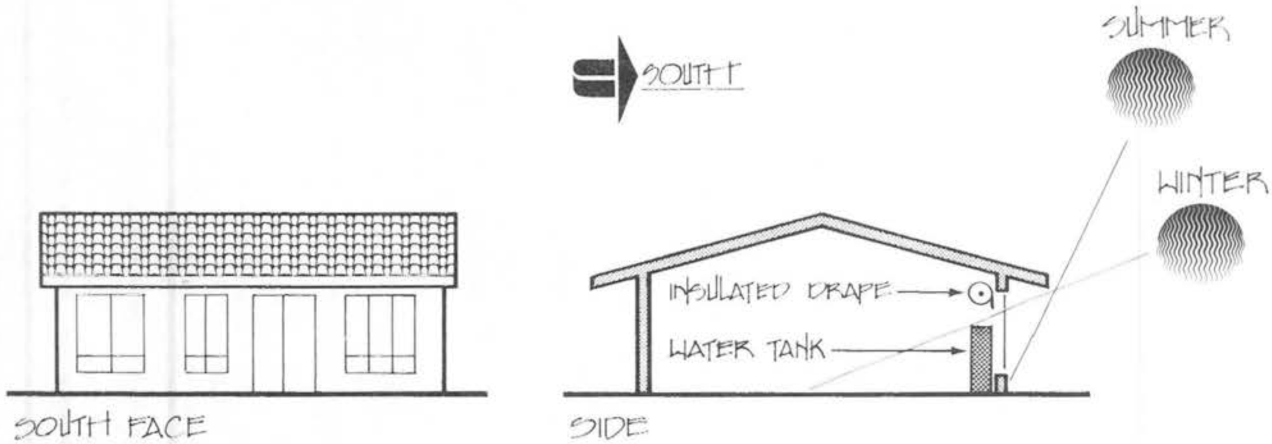



FIGURE 1: A Basic Passive House, the Most Common Passive Solar Design

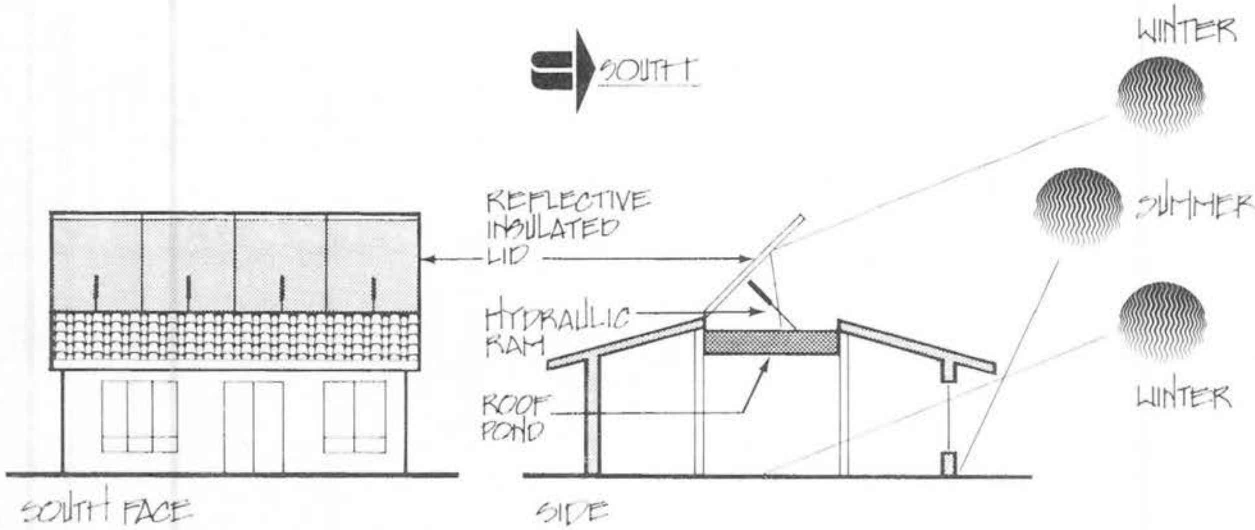



FIGURE 2: A More Sophisticated Passive House, Suitable for Hotter Climates

Passive systems are presently the most cost-effective of all solar systems. Even a standard house can be a good direct solar house if it is oriented and designed properly. A recent Energy Commission study demonstrated that, with only minor and inexpensive changes in design, a standard house could function as a passive solar system (see Table 1).

| | Standard House With Shading % Cooling | % Heating | With Thermal Mass % Heating | % Cooling |
|---|---|---|---|---|
| San Jose | 40 | 29 | 74 | 100 |
| Contra Costa | 28 | 26 | 68 | 100 |
| San Diego | 27 | 47 | 100 | 86 |
| Orange County | 27 | 33 | 96 | 86 |
| Riverside | 26 | 35 | 96 | 94 |
| Sacramento | 26 | 25 | 65 | 99 |
| Los Angeles | 24 | 42 | 86 | 100 |

TABLE 1: Percentage of heating and cooling needs that could be met by passive solar systems in California homes.

The second type of solar system is the ACTIVE system. These systems collect the sun's energy in one place and then transfer it with pumps, flat-plate fans or thermosiphons to a separate storage area. A flat-plate solar water heating system is a common example of an active system. Active systems are more expensive than passive solar systems, but are cost competitive with electricity and, in some areas of California, even with gas. They are particularly well-suited for space heating in colder areas or for water heating, but they can provide only limited cooling. A typical system is shown in Figure 3.

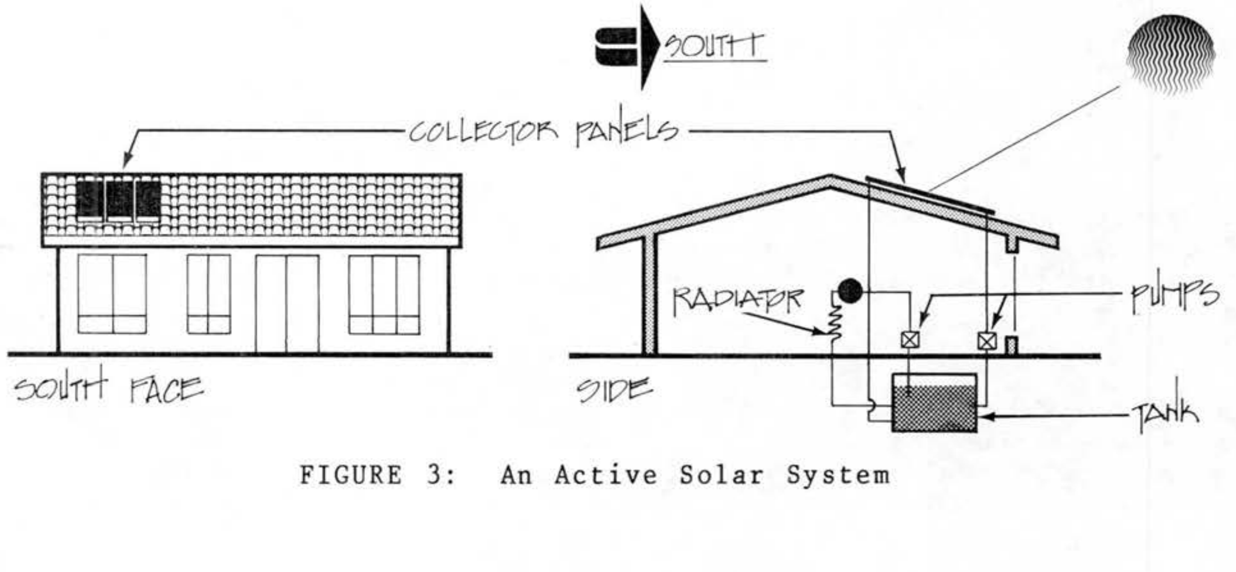



FIGURE 3: An Active Solar System

## 3.0 SOLAR ACCESS REQUIREMENTS

Both PASSIVE and ACTIVE solar systems require exposure to the sun for heating. In addition, the PASSIVE system may need good exposure to the night sky for cooling.

The Solar Access Requirements of solar systems may be defined as the necessary field of view required to provide useful amounts of heating or cooling. This field of view or skyview will vary depending on four variables:

- o Placement, type, and function of the collector (roof, southwall, space conditioning, water heating, etc.).
- o The yearly use pattern.
- o The daily use pattern.
- o Site and environmental factors.

### 3.1 Collector/Dissipator Position

Figure 4 illustrates the primary winter heating skyviews for the four basic collector positions. The ground-mounted collector is the most difficult to protect as it is the lowest and most susceptible to shading from neighbors to the south. Detached or roof-mounted collectors usually pose the fewest problems as they are the highest. Generally, the winter sun exposure is the most critical and is more difficult to protect because the sun is very low in the sky (see Appendix 2, Sunpath). Summer heating skyviews are easier to protect because the sun is higher in the sky.

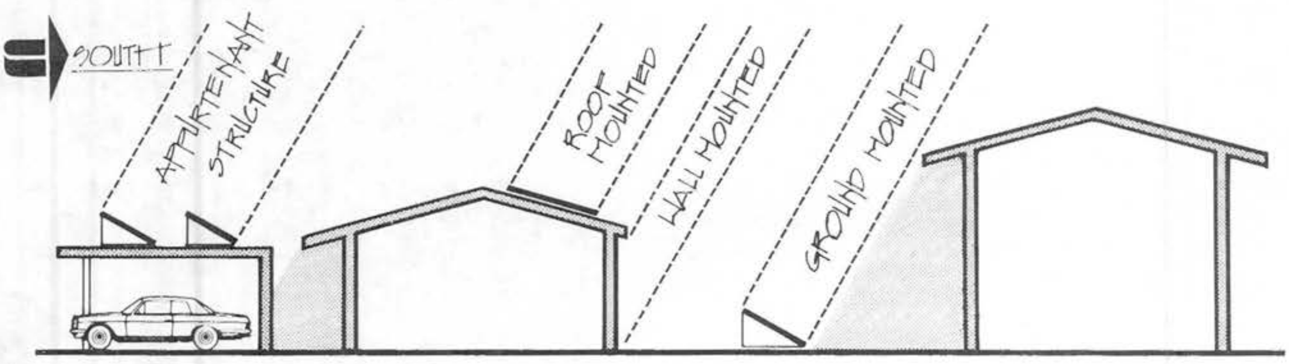



FIGURE 4: Collector Position

### 3.2 The Yearly Use Pattern

The yearly use pattern is also an important factor in determining solar access requirements. The three basic uses are:

- o Winter heating only (primarily space heating).
- o All year heating (primarily domestic hot water).
- o Cooling.

The requirements for skyview in each of these categories depend on the length and intensity of the cold period, the hot period, and the desired percentage of service for the collector system. For example, a solar system which is designed to provide 100 percent of a building's heating may have much more stringent access requirements than a similar collector which is only expected to meet 80 percent of the heating demand.

The following describes some of the solar access considerations for the uses listed above.

3.2.1 Winter Heating Only

Winter solar space heating is one of the most common and cost-effective uses of solar energy. The solar access requirements for space heating depend on the length and intensity of the cold period, the comfort requirements of the occupants, and the solar system design. The length of the heating season, latitude, and microclimate determine the best type of solar system and the best heating season skyview for a particular area. The nature of the cooling season might also determine the desired type of heating system. For example, an integrated system might be more cost-effective than a "heating only" solar system.

The skyview requirement for space heating depends on collector position, orientation, use pattern, site, and other factors. The heating season skyview requirements are shown in Figure 5, for PASSIVE and ACTIVE solar systems in a relatively clear area at 40°N (near Sacramento) with a heating season from August 21 to April 21. The PASSIVE system skyview is shown with a solid line and the ACTIVE system skyview is shown with a dotted line. The less expensive PASSIVE system has a more restrictive skyview than the more expensive active system.

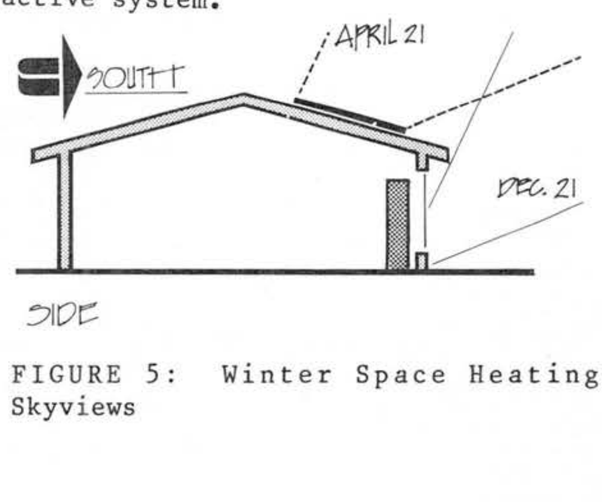



FIGURE 5: Winter Space Heating Skyviews

3.2.2 Year-Round Heating

Year-round heating for domestic hot water usually requires exposure to the direct sun throughout most of each day all year. The sites and type of collector systems can vary widely but the skyview requirement remains virtually the same (Figure 6).

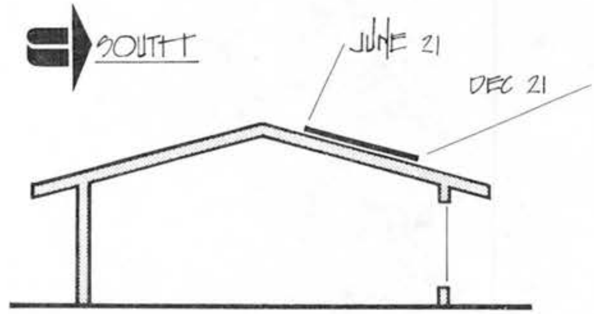



FIGURE 6: Year-Round Water Heating Skyview

3.2.3 Space Cooling

The requirement for natural cooling depends on the length and intensity of the cooling load and the comfort requirements of the occupants. The type of building, the diurnal temperature variation, humidity, and other factors determine the type of space cooling used. The most common PASSIVE solar systems use cool night breezes for convective cooling in the summer. Thus, they require solar access only in the winter. More sophisticated passive solar systems designed for cooling may use the cold night sky, the cool north sky, evaporation, and convection.

In many areas, both PASSIVE space heating and cooling are desirable. In these areas, the skyviews for both heating and cooling must be known and incorporated in planning and design. The skyviews are illustrated in the cross-section (Figure 7).

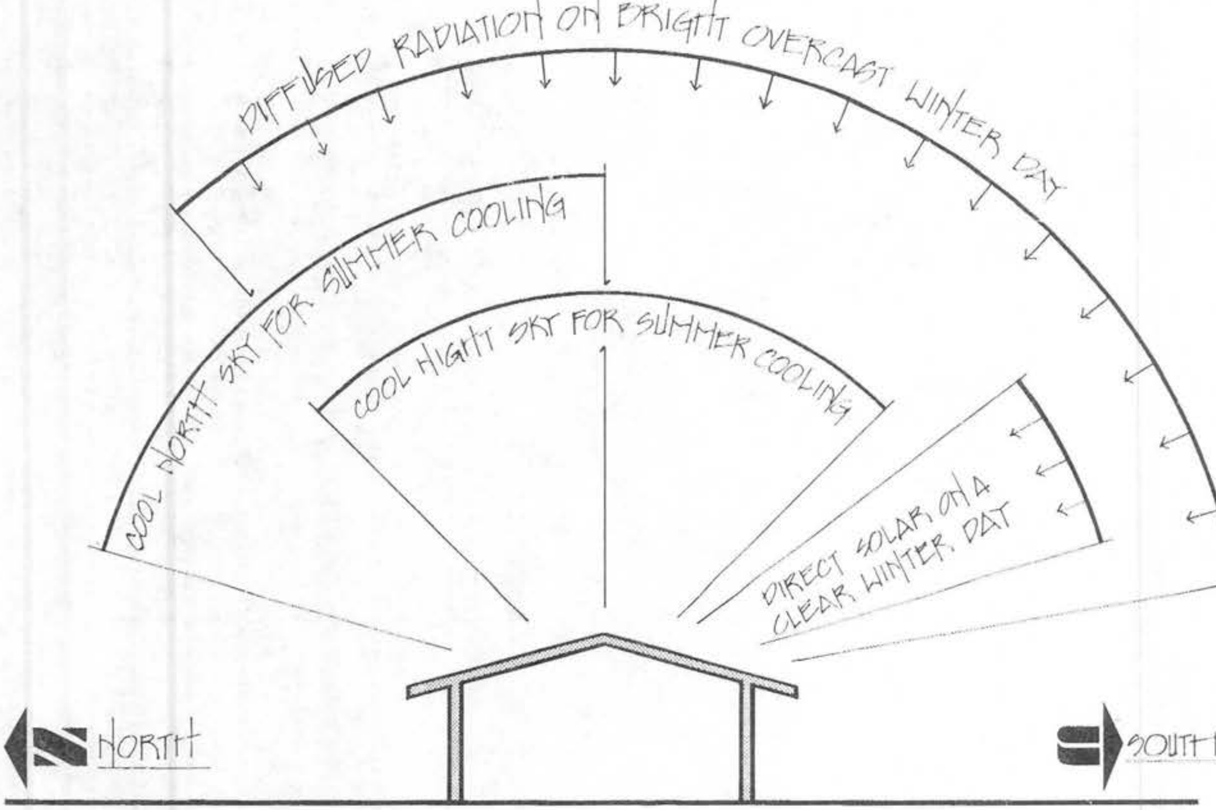



FIGURE 7 - Integrated Skyviews for Heating and Cooling

3.3 Daily Use Pattern

The daily use pattern also influences solar access requirements. Here, the balance of night vs. daytime temperatures, pattern of available energy, and pattern of needed energy predominate.

The collector can be oriented to provide either extra morning heating, balanced heating, or extra afternoon heating. Early morning heating is often desirable in winter in a solar tempered house as heat storage from the previous day may be limited and a prompt warming can be very welcome.

The daily use pattern of a collector can help determine skyview requirements. For example, if large quantities of hot water are desired early in the day, the solar collector for the domestic hot water should be oriented somewhat to the east of south so that the peak collection period comes before noon.

3.4 Site and Environmental Factors

Many environmental factors significantly affect solar system performance and therefore planning for solar access.

The basic environmental and site factors which affect solar access include: climate and microclimate; latitude; topograpy; vegetation; and human's activities and structures.

3.4.1 Climate and Microclimate

We are all familiar with our local

climate and have an image of what it is like. These images are often overly general and tend to neglect the many small-scale, microclimatic conditions which may vary widely. Although regional classifications are useful, they tend to mask the influence of local variations which may significantly increase or decrease individual heating or cooling requirements.

The design and construction of a development create a new microclimate, which can be better or worse than the existing climate depending on the skill and understanding of the designer and his or her analysis of local microclimatic conditions. A "warm pocket" might require very limited solar access to maintain comfort while a "cold spot" might require full solar exposure. The Energy Commission is now developing aids for identifying the favorable and adverse factors for specific local climates.

3.4.2 Latitude

The change in the sun's path at different latitudes in part determines solar access requirements. Figure 8 illustrates the change in altitude and azimuth in the south, middle and north latitude of California. The sun is lower in the sky in the northern area of California than in the southern area, making solar access more difficult to protect.

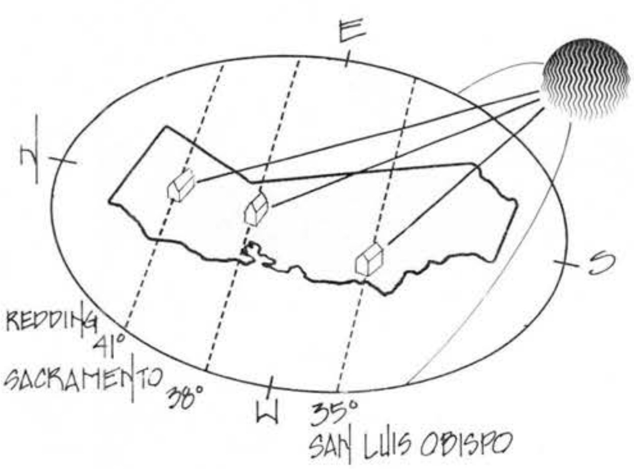



FIGURE 8.A: Communities in the north (at higher latitudes) see the sun at a lower altitude than communities in the south (at lower latitudes).

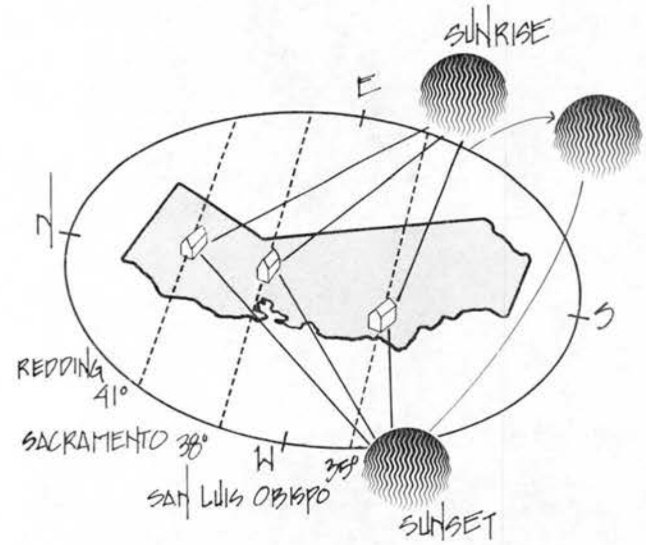



FIGURE 8.B: The winter sun traverses a smaller section of the sky when viewed from the north.

FIGURE 8: Sun Angles and Latitude

3.4.3 Topography

The topography of a site exerts a considerable influence on the daily and seasonal patterns of solar radiation. On a steep north-facing slope little direct radiation is received at any time during the year, while a south-facing slope will consistently receive direct sun (Figure 9). Consequently, developers may wish to put dense housing developments on the south slopes and leave the north slopes for open space or low density development.

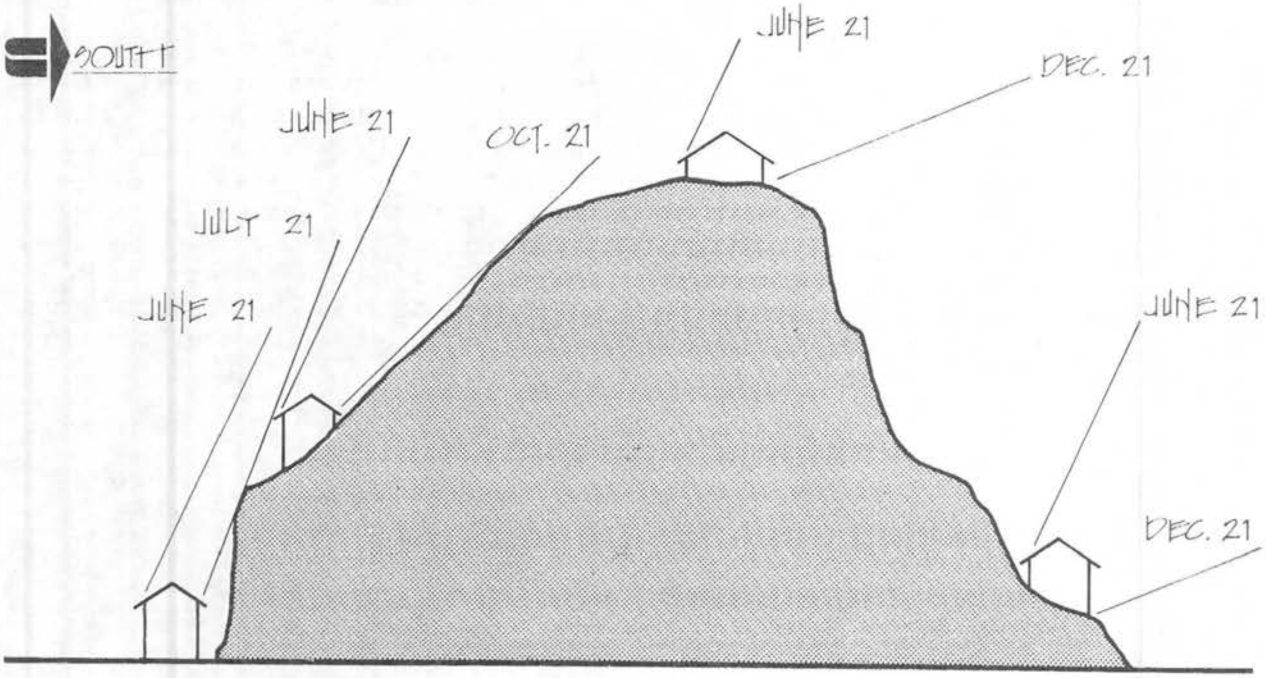



FIGURE 9: Topography and Skyview

3.4.4 Vegetation

In most areas, vegetation is the most critical factor affecting solar access. Typical residential planning practice ensures good solar exposure for roof collectors with any street orientation, but does not protect the collectors from shading caused by vegetation. Solar exposure for south wall and ground collector systems on east-west streets is usually limited only by shading from vegetation. Inasmuch as shading from the bare limbs of deciduous trees can reduce the amount of solar radiation reaching a collector by 25 percent or more, placement of trees is critical. Shading from evergreen and deciduous trees in the summer can render a solar hot water system inoperable.

Even when the structure is not fully shaded by vegetation, its skyview may be limited. A site with a tree or trees to the south may still have sufficient solar exposure for operation if a significant skyview remains available. For example, if a tree to the southwest (see Figure 10) blocks the afternoon sun, the collector can be shifted slightly to the east. This will shift the skyview to the east as well. This easterly solar radiation compensates for the afternoon (westerly) radiation that is blocked by the trees.

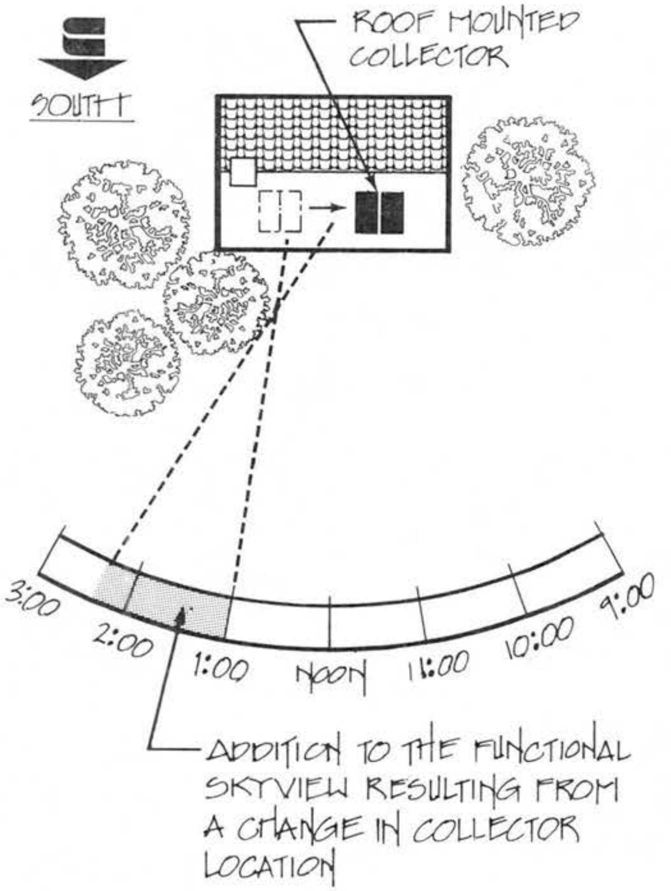



FIGURE 10: Skyview Shift

Properly placed trees can provide great energy savings in the summer by shading and cooling buildings and by providing good solar access and reducing wind cooling in the winter. Choosing the type of tree is also important. Deciduous shade trees should provide full shade in the summer and an open branching pattern in the winter. For wind control on the north, evergreen trees may be best (Figure 11).

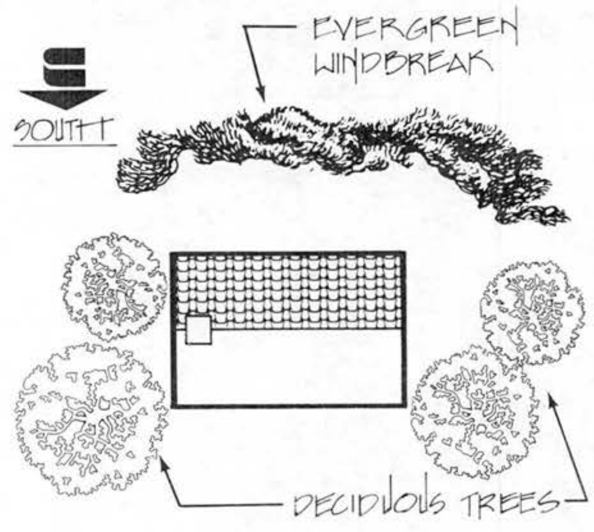
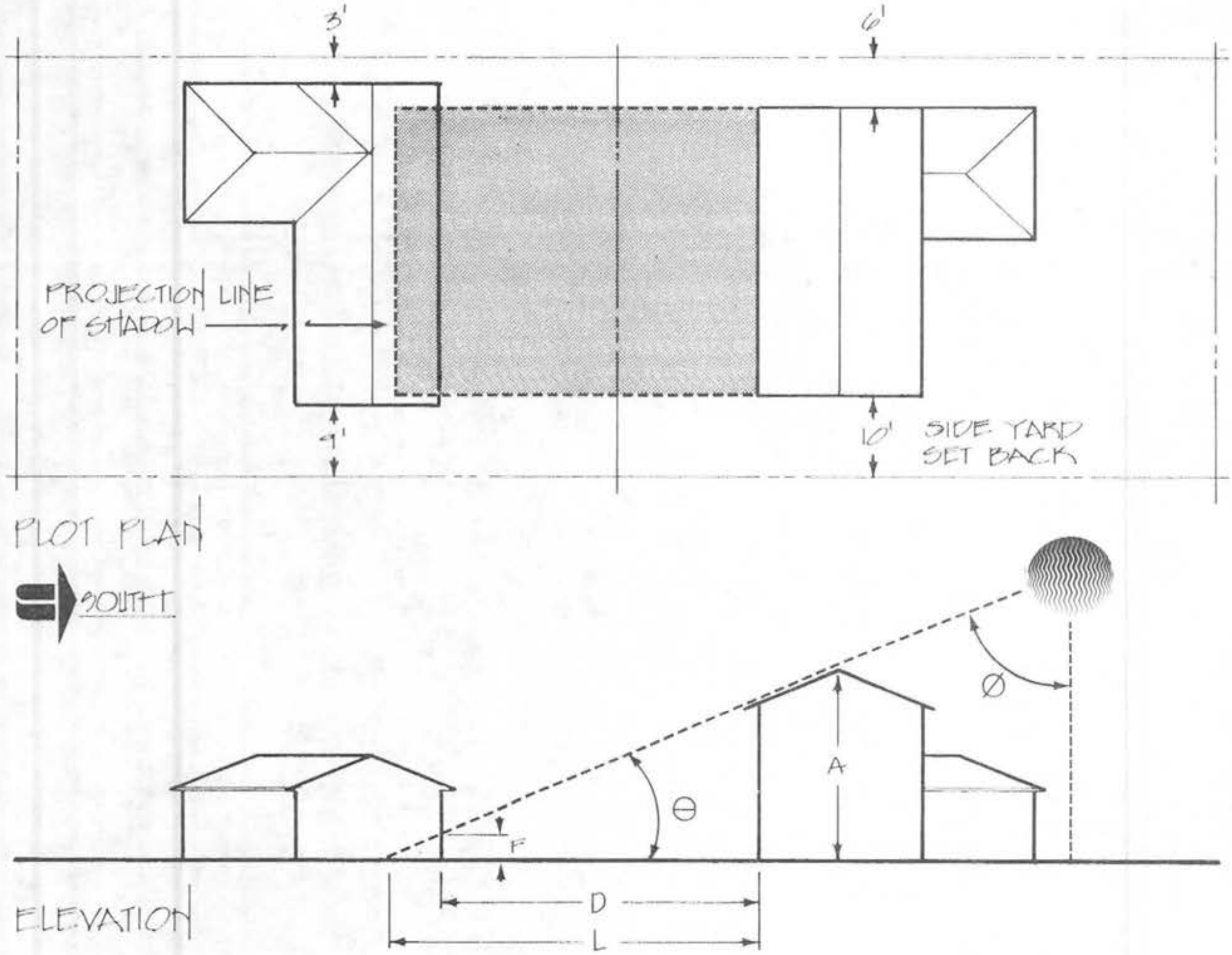



FIGURE 11: Planting For Solar Access Can Provide Needed Sun and Shade

3.4.5 Social Impact

Human activities may also have a significant impact on solar exposure and local microclimate. Buildings, for example, affect both solar exposure and wind flow. Well-designed streets and buildings can reduce energy use for heating and cooling and increase human comfort. If solar access is ignored in design and planning, structures may be fully shaded and the possibility of using solar systems may be foreclosed.

With proper site planning, most structures can be located on a lot so the solar access of neighboring properties is protected (Figure 12).




A = HEIGHT OF TALL BUILDING
D = DISTANCE BETWEEN BUILDINGS
F = HEIGHT OF SHADOW
L = LENGTH OF SHADOW
Ø = ANGLE DESCRIBING THE SUN'S ALTITUDE AT NOON ON DECEMBER 21.
Θ = FOUND IN ASHRAE HANDBOOK OF FUNDAMENTALS FOR VARIOUS LATITUDES

HEIGHT OF SHADOW ON BUILDING = $F = [(\text{LENGTH OF SHADOW}) - (\text{DISTANCE BETWEEN BLDGS.})] \times \tan\Theta$

$= [(\tan \varnothing)\, A - D] \times \tan\Theta$

SOURCE : COMMUNITY DEVELOPMENT
CITY OF DAVIS, CALIFORNIA

FIGURE 12: TYPICAL SHADING DIAGRAM

## 4.0 PLANNING FOR SOLAR ACCESS

The description of solar access requirements in Section 3 provides a useful introduction to this section which includes a brief description of the critical issues in solar access planning and how they affect development design.

### 4.1 Trees

Trees are a vital factor in solar access planning. But the planner must bear in mind that trees, unlike houses and streets, change dramatically over time. If planted wisely, trees can provide needed summer shading without blocking collectors (Figure 13). Summer shading for houses is needed most on the east and west exposures, not the south as might be expected (see the sun path diagram in Appendix 2).

Street trees are of particular importance, because they are chosen and maintained by the city. Full, rounded street trees can reduce neighborhood temperatures by 10-15°F.

The type of tree is, therefore, critical and should receive careful study and consideration. The current policy in most cities has been to select trees which are short, thin, and retain their leaves all year. This policy may afford the lowest maintenance cost, but it provides few other benefits. The energy and money savings from full summer shading and solar exposure in the winter with deciduous trees more than offsets the cost of increased maintenance. Sometimes shorter trees on the north side of a street and taller trees on the south improve solar access (see Figure 14).

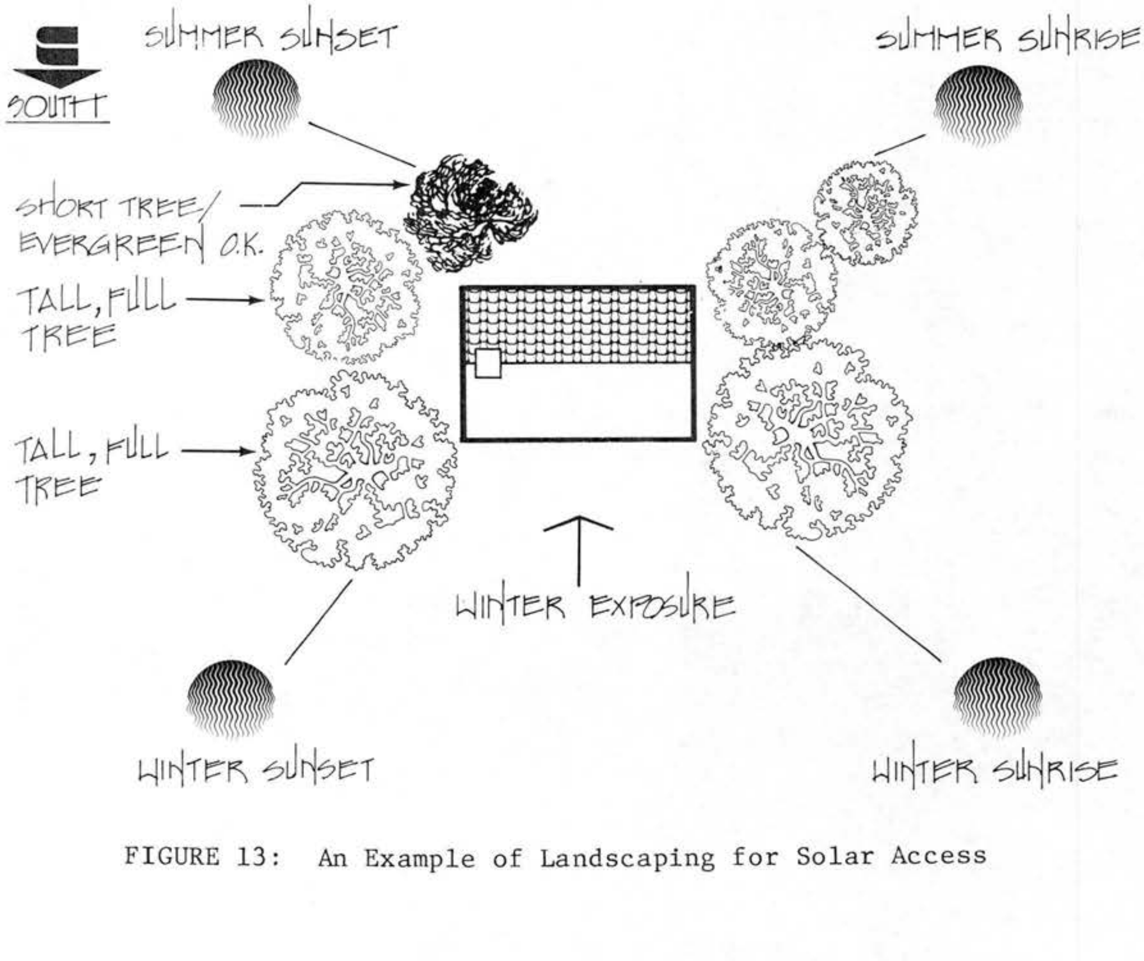



FIGURE 13: An Example of Landscaping for Solar Access

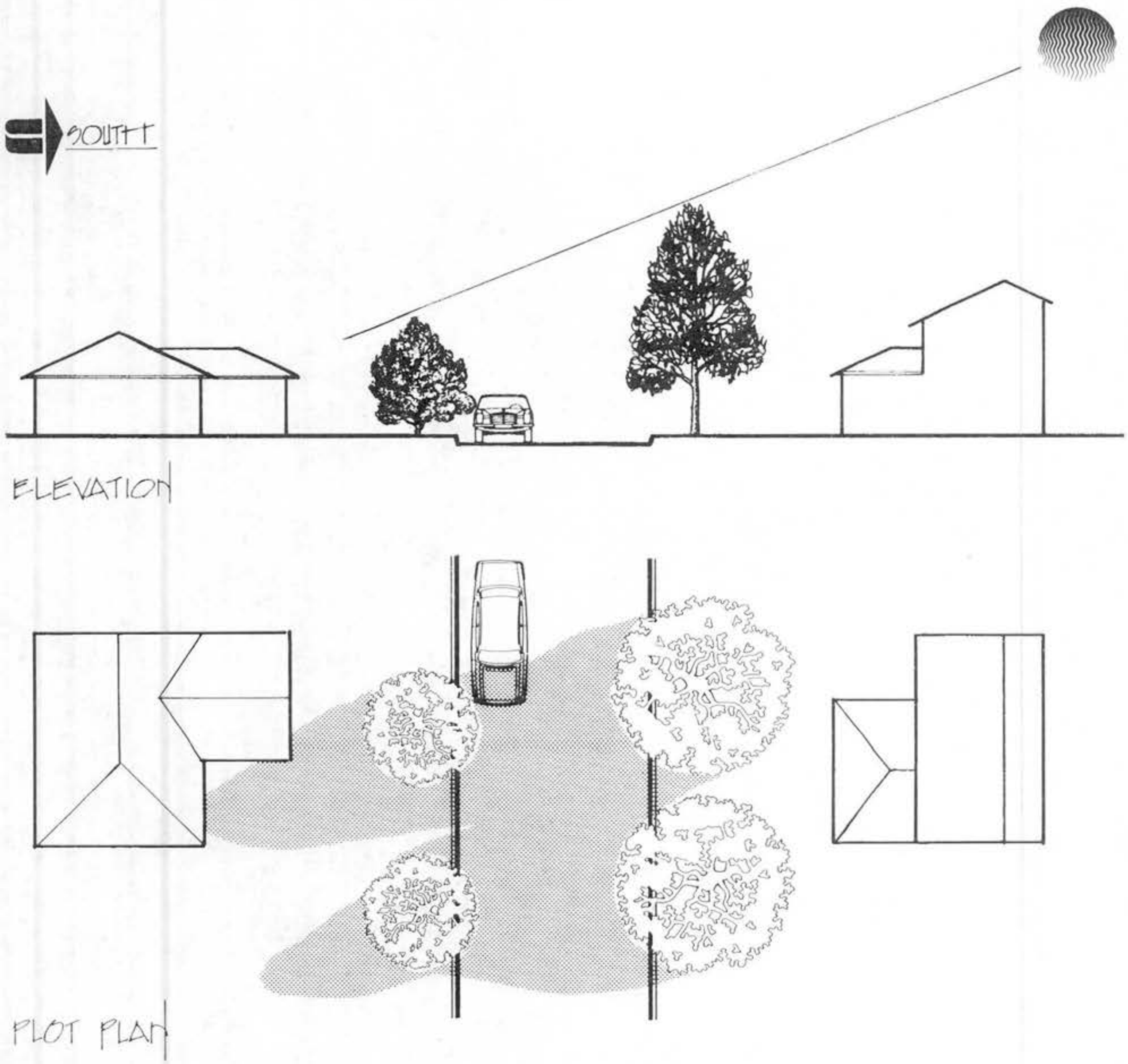



FIGURE 14: Shorter Street Trees on the North Side of a Street Increase Solar Access

Trees and shrubs can also improve ventilation. This is helpful for convective cooling in areas with cool night breezes. The trees and shrubs act almost like a dam in a river and direct the cooling breezes through the windows for summer cooling (Figure 15).

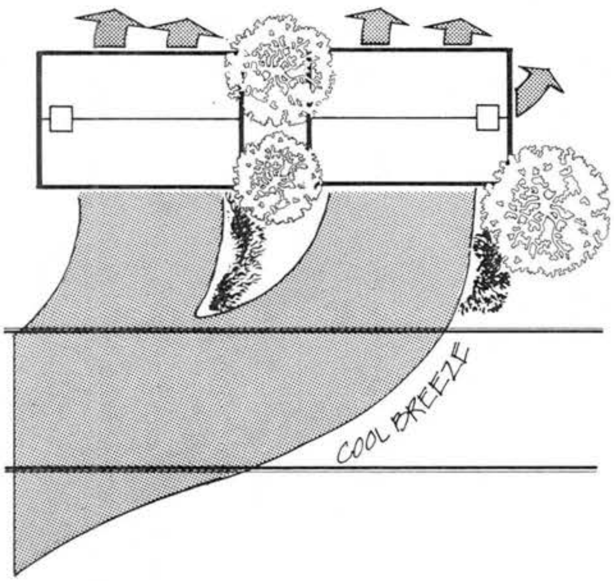



FIGURE 15: Trees and Shrubs Can Help Natural Cooling

4.2 Street Orientation

In most areas, street orientation is as important as tree placement. Street orientation usually determines house orientation--the houses face the street and have major yards to the front and back. In California, streets should be oriented east and west, with minor bends, so that houses can have a major yard to the south. This orientation ensures that most houses will be passive or semi-passive solar houses with lower heating and cooling bills (Figure 16). If streets run north-south, active solar systems (roof collectors) usually work better than the less expensive passive solar systems as the skyview is often highly restricted (Figure 17).

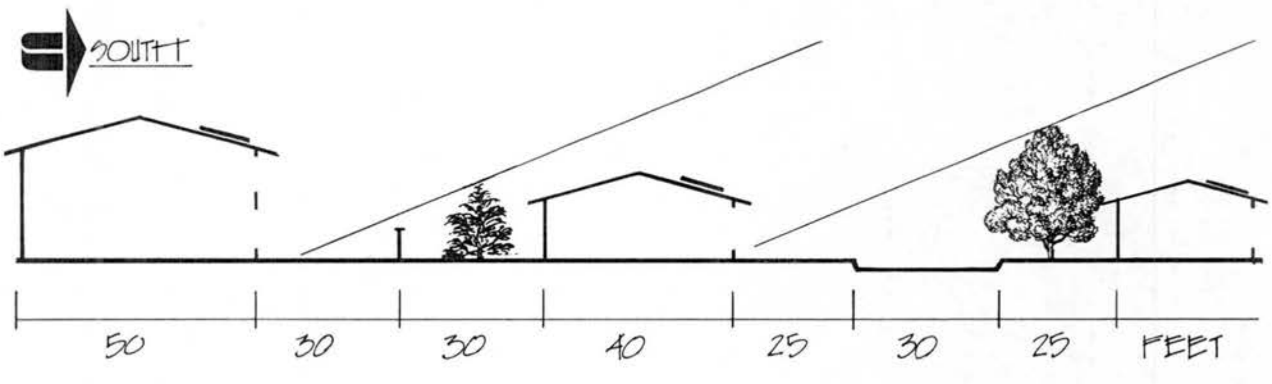



FIGURE 16: Solar Access With East- West Streets and Typical Setback

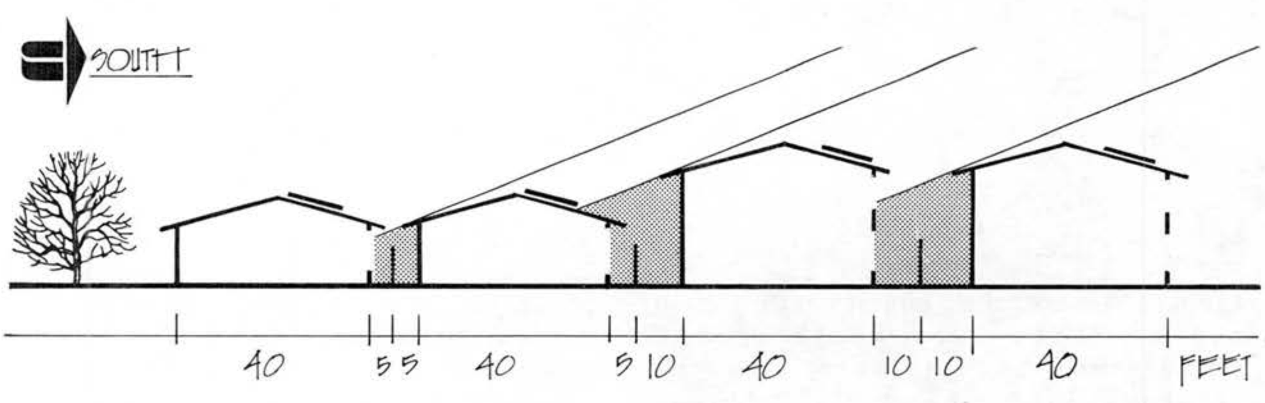



FIGURE 17: Solar Access on A Typical Suburban North-South Street with Sideyard Setbacks

In most flat areas, predominantly east-west street direction can be set during development design at no increase in cost. The following plans (Figure 18) show how streets were reoriented in a Davis development to meet this objective. The number of housing units remained unchanged.

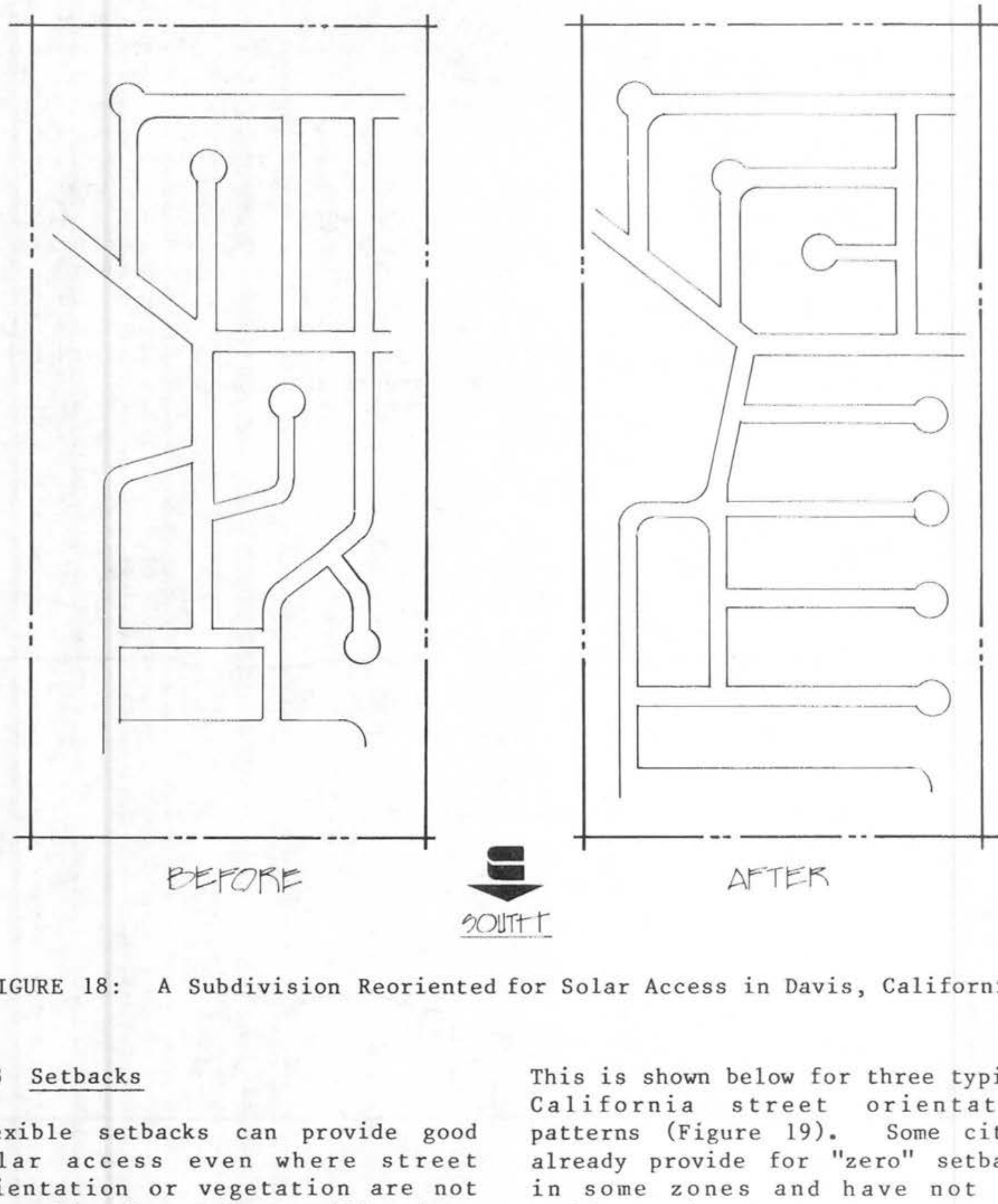



FIGURE 18: A Subdivision Reoriented for Solar Access in Davis, California

## 4.3 Setbacks

Flexible setbacks can provide good solar access even where street orientation or vegetation are not favorable for solar utilization. This is shown below for three typical California street orientation patterns (Figure 19). Some cities already provide for "zero" setbacks in some zones and have not had problems using them.

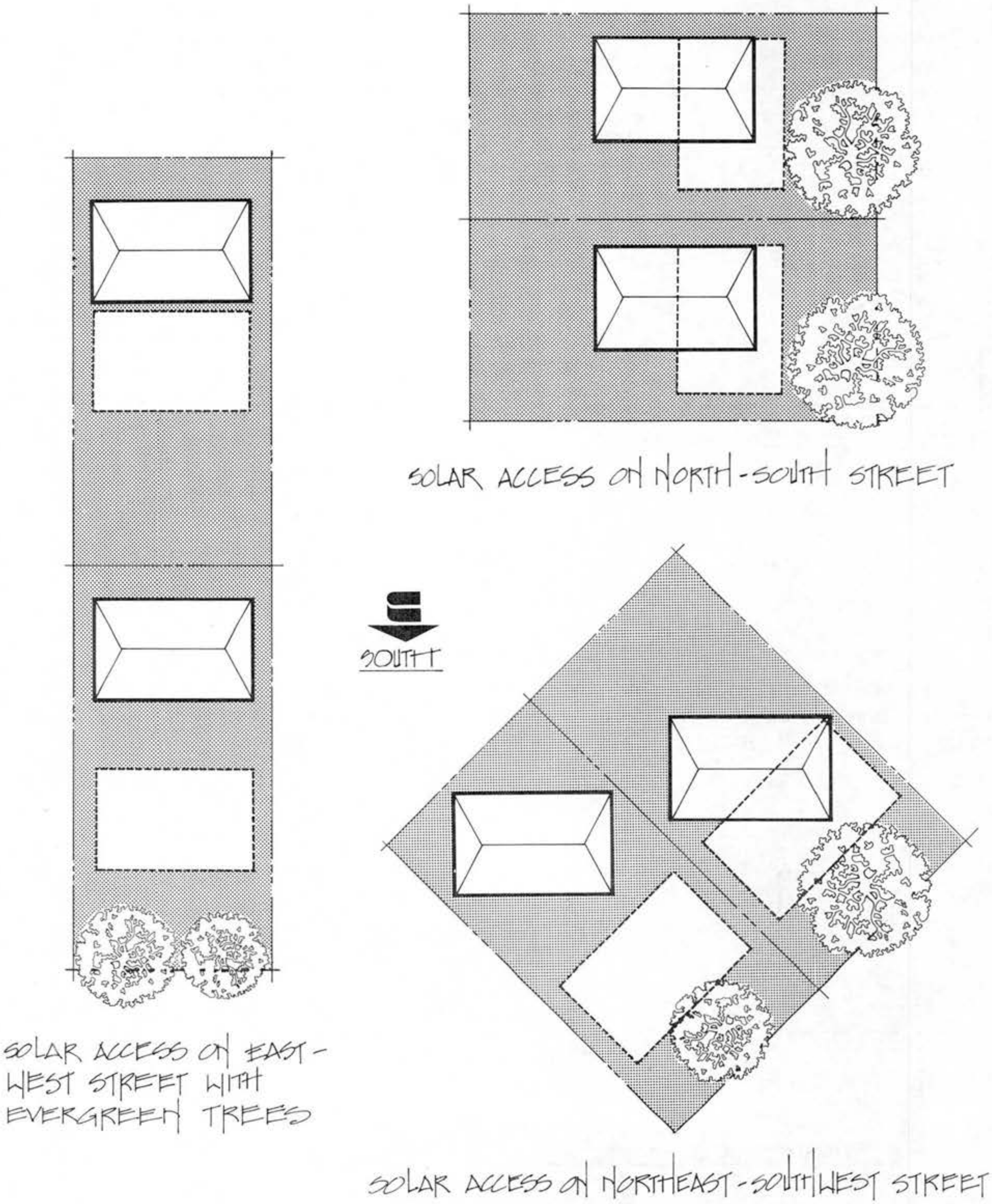



FIGURE 19: Solar Access - Typical Setback Changes Required

4.4 Fences

In many areas, existing fence regulations also discourage or prevent homeowners from using passive solar heating and natural cooling. The most common problem is the distance fences must be from the street. For a house with a south-facing front yard, a fence may block most of the winter sun from the windows. A reasonable reduction in fence setback can provide needed solar access for effective winter heating (Figure 20).

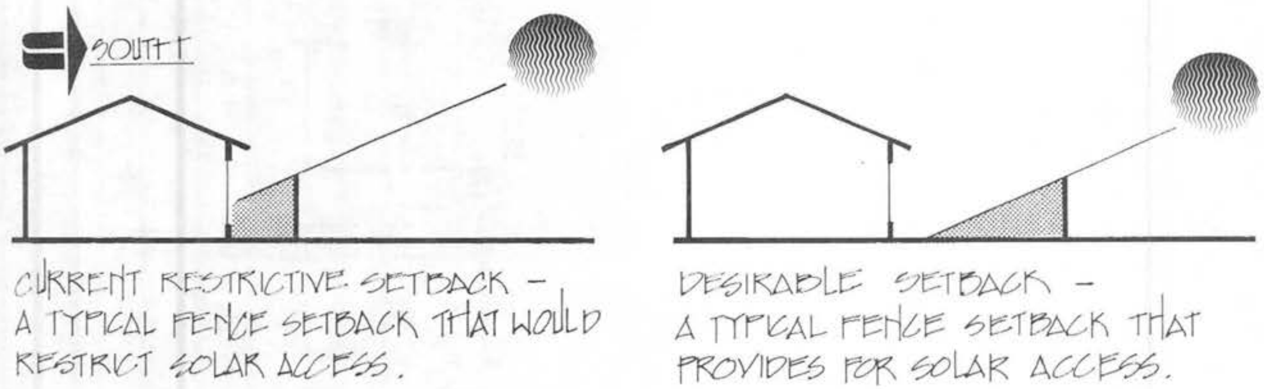



FIGURE 20: Fence Setback for Solar Access

4.5 Height Restrictions

The height restrictions in single-family developments provide reasonably good solar access in most cases; however, when multi-family housing and single-family housing are mixed, existing restrictions may not protect solar access. Relatively simple changes in design may provide this

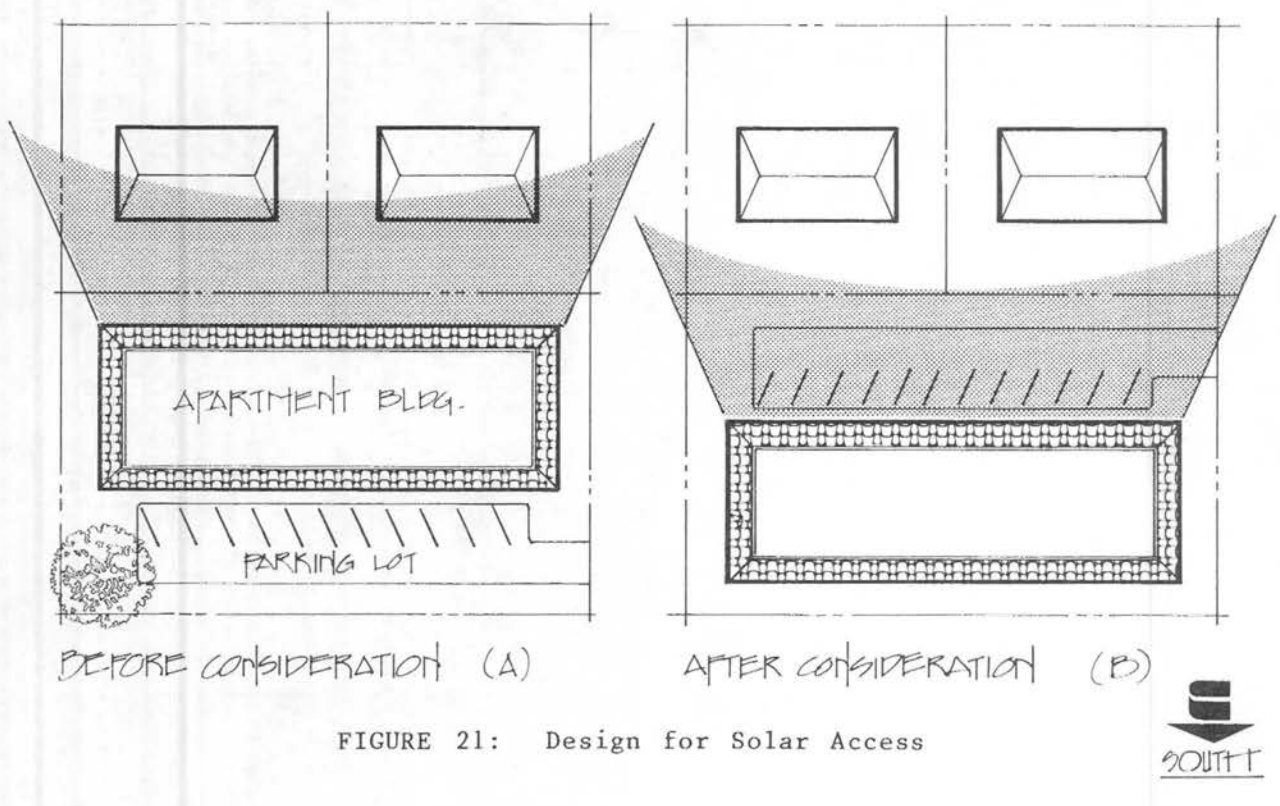



FIGURE 21: Design for Solar Access

access at no additional cost. Figure 21 A and B illustrates adding an apartment to a residential area of single-family dwellings. The shaded area represents the shadow pattern of the same apartment building for two sites on a lot. Building placement B guarantees solar access to the single-family homes. An alternative design of the new building could also accomplish this with no reduction in density.

4.6 Street Width

Street width can also be used to improve solar access. Narrower streets allow street trees to be placed farther from houses and thus reduce unwanted shading. Narrower streets also provide direct cost savings for the developers and/or local governments for construction and maintenance. In addition, the narrower streets are easier to shade during the summer.

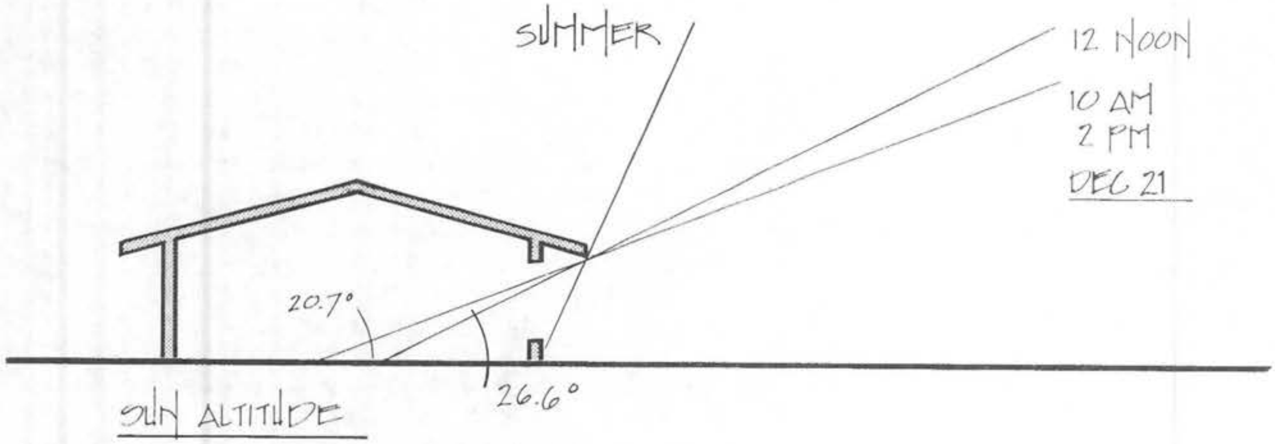
5.0 SOLAR RIGHTS

Inasmuch as large investments are required for some types of solar heating systems, a guarantee of "solar rights" in new residential developments should be developed to provide protection for solar home owners.

The legal protection of solar access through "solar rights" can be accomplished in new developments using either easements or covenants. This will be particularly easy in areas where most development occurs in planned unit development (PUD). In existing developments the problem is more difficult because buildings and vegetation may already block the sun. The most reasonable approach here may be simply to review carefully future changes in landscaping and structures in order to determine the best ways to use the sun. The City of Davis has included sun exposure as an element in its Environmental Impact Reviews and this might properly be extended to other areas.

Another concept which may be worth exploring is solar zoning. With only minor modifications most municipal zoning ordinances can be amended to provide for solar access. One method of doing this is with solar envelope zoning as illustrated in Figures 22 to 24. In this case the building envelope of each lot, as is currently defined by the local zoning ordinance, is modified to provide for solar access to the home owner's lands.

The use of solar energy is widespread and increasingly valuable, not only for people with solar houses but also for existing buildings with good orientation. As energy prices continue to rise, "solar rights" will be even more important, and considerable legal action may ensue unless "solar rights" are more clearly defined. In the interim solar access can be safeguarded by the planning practices outlined here.



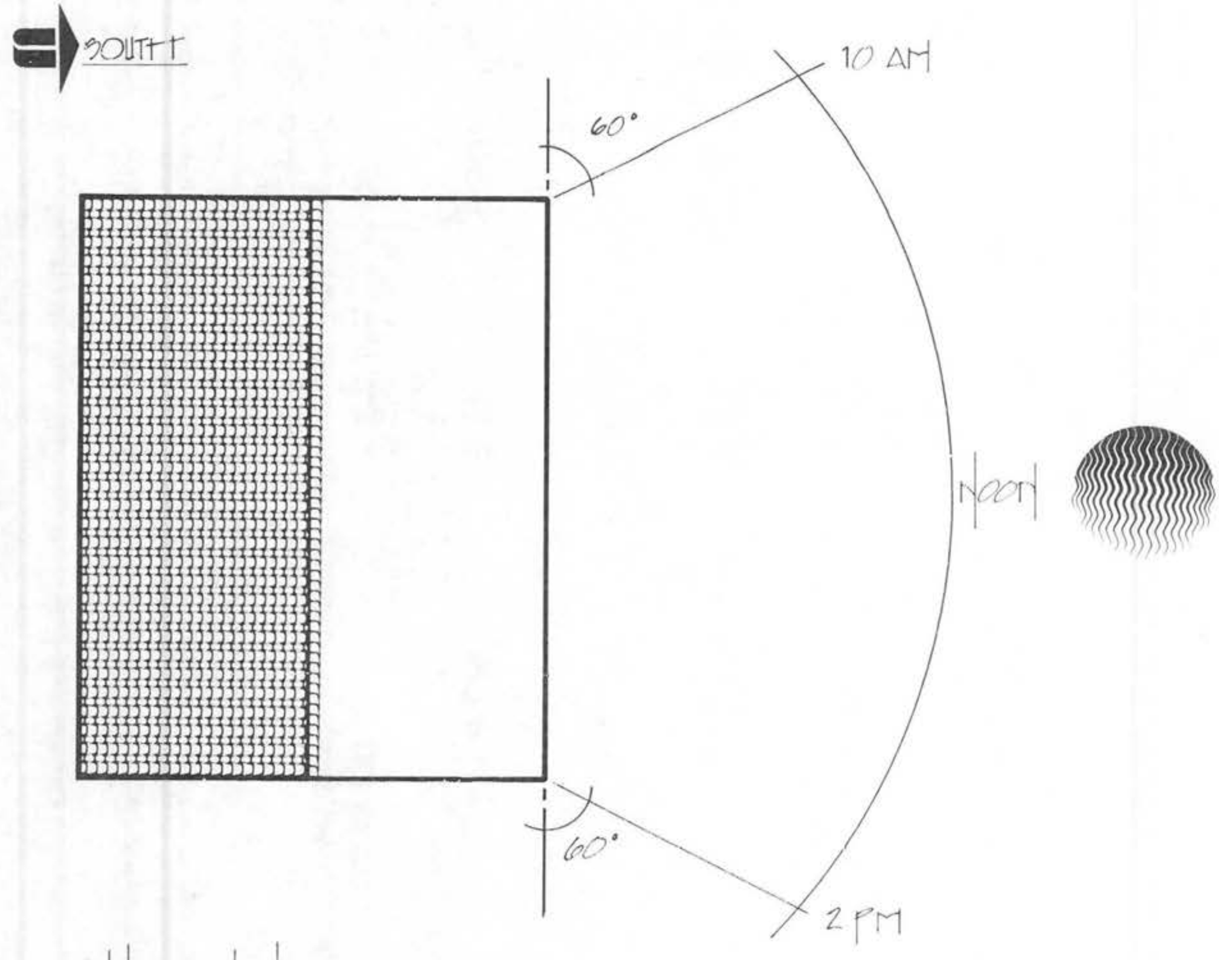




FIGURE 22: Solar Access - The Winter Sun

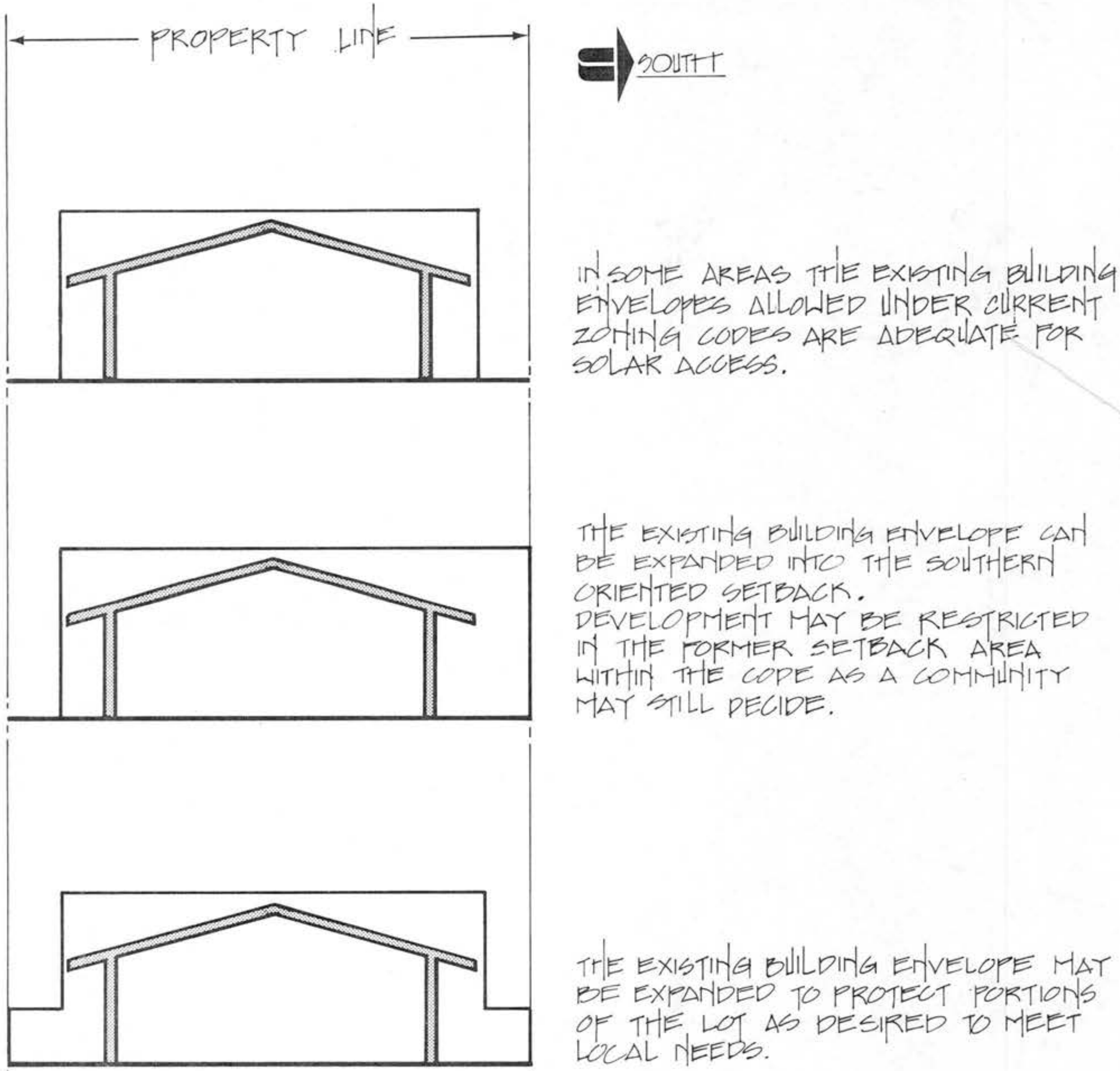
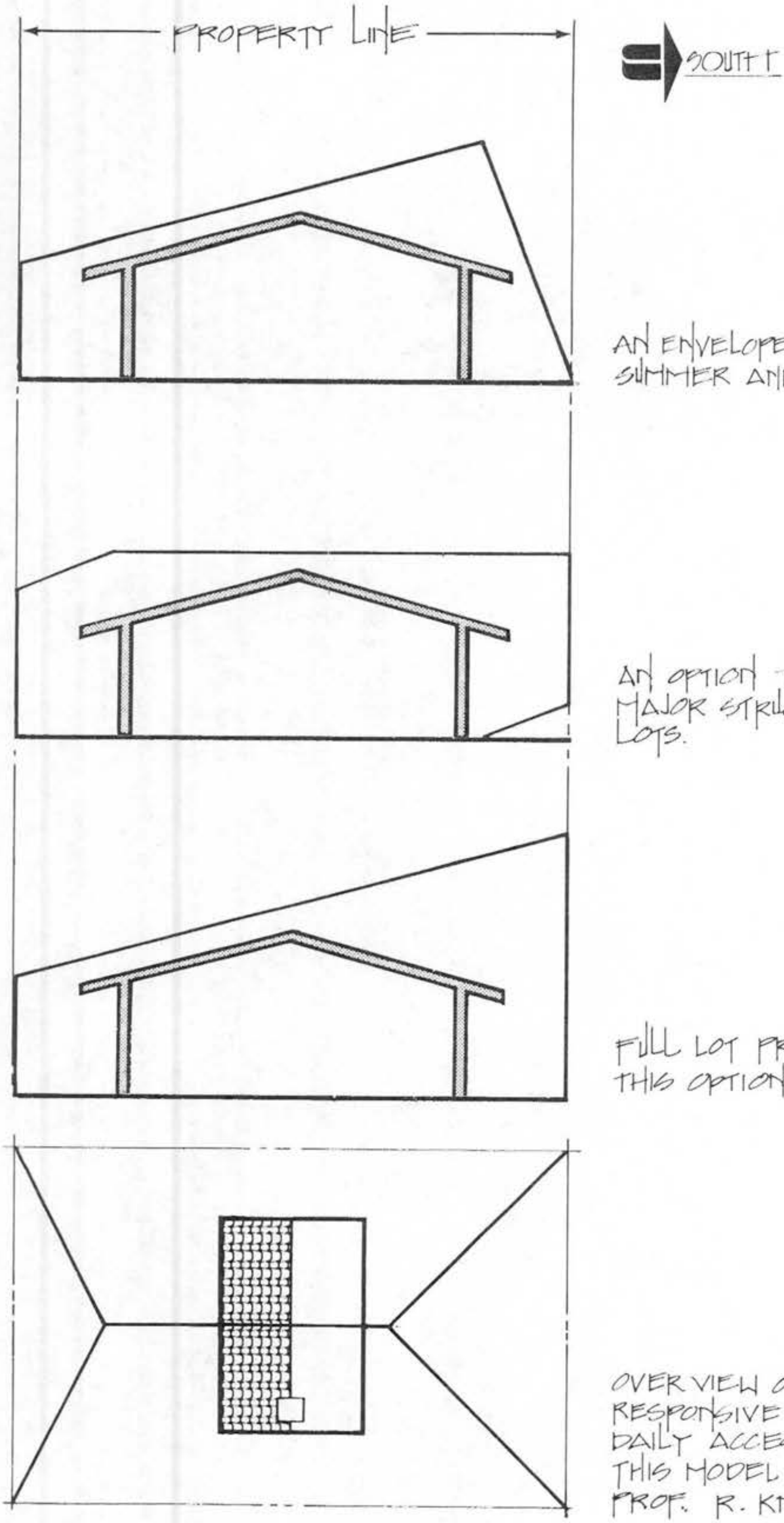



FIGURE 23: Possible Shapes for Envelope Zoning




AN ENVELOPE DESIGNED TO PROTECT BOTH SUMMER AND WINTER ACCESS.

AN OPTION THAT ALLOWS ACCESS TO MAJOR STRUCTURAL AREAS ON SMALLER LOTS.

FULL LOT PROTECTION IS GRANTED IN THIS OPTION.

OVERVIEW OF AN ENVELOPE THAT IS RESPONSIVE TO A SEASONAL AND DAILY ACCESS REQUIREMENT.
THIS MODEL HAS BEEN DEVELOPED BY PROF. R. KNOWLES OF U.S.C.

FIGURE 23 (cont.): Possible Shapes for Envelope Zoning

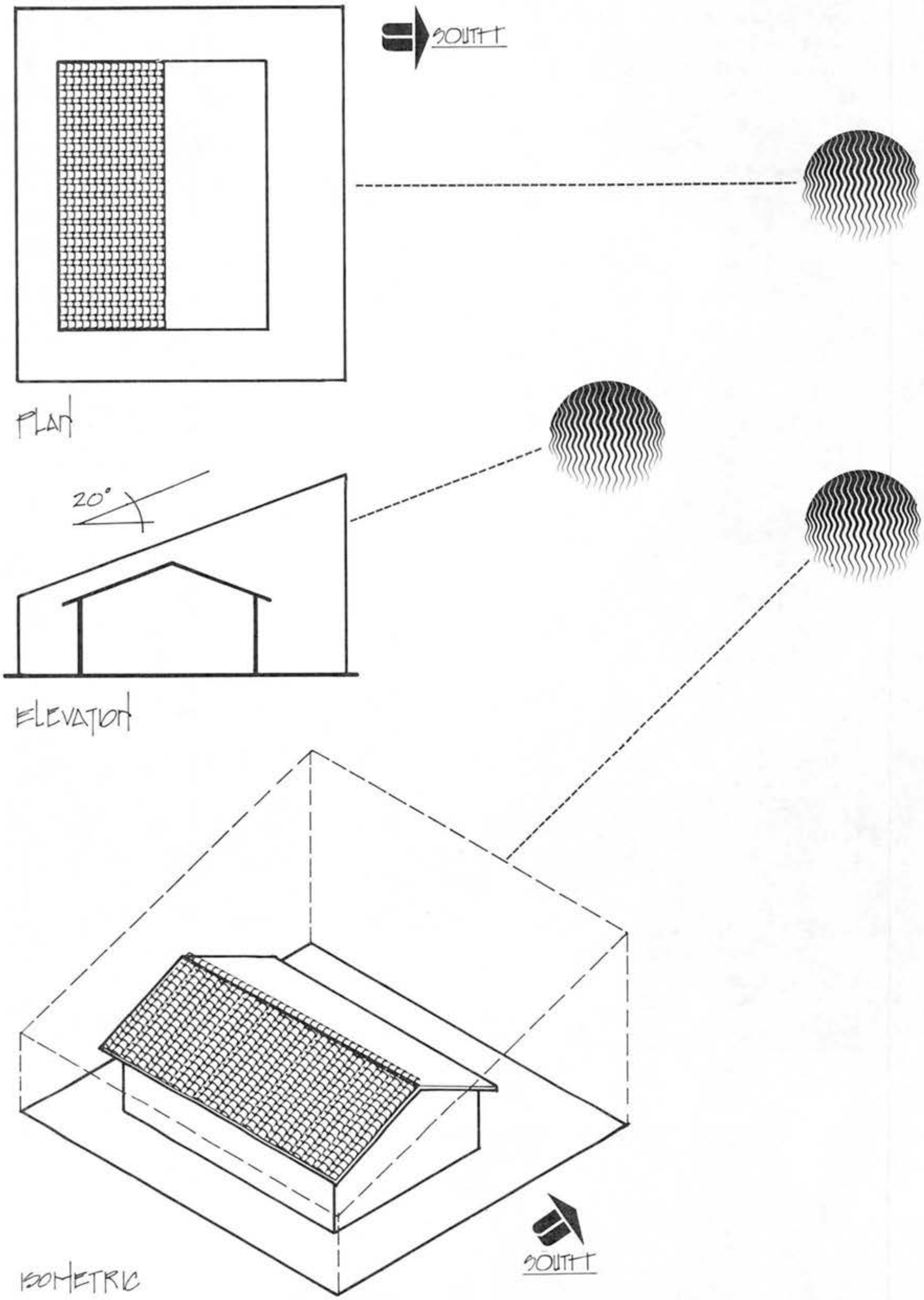
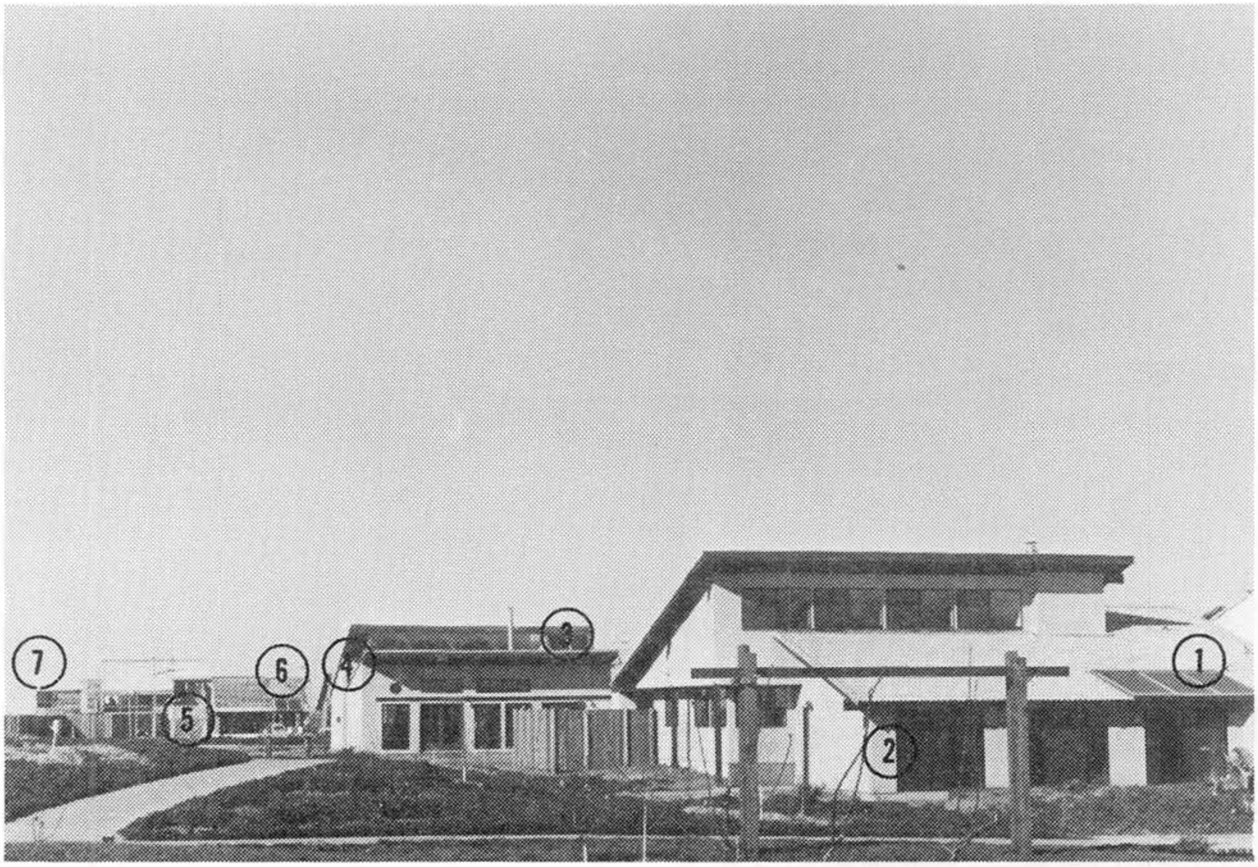



FIGURE 24: Envelope Zoning - An Illustration

## 6.0 A SOLAR SUBDIVISION

Most of the solar access provisions proposed here are already common practice in several areas of California (quite often for reasons other than solar access). The best example of a solar development in the United States incorporates many of these considerations. The development, Village Homes, is in Davis, California. The following photos show how this solar development is designed and how it looks. All of the houses have large south-facing surface areas and incorporate basic passive design features. Many include more complete solar systems and achieve 80 to 90 percent heating and full cooling.

Basic Solar Homes in Village Homes




VILLAGE HOMES - A SOLAR SUBDIVISION

1) ACTIVE: THERMOSIPHON HOT WATER HEATER

2) PASSIVE: DIRECT GAIN HEATING AND CONVECTIVE COOLING

3) PASSIVE::BREADBOX HOT WATER HEATER

4) PASSIVE: SUNCATCHER WATER WALL HEATING AND CONVECTIVE COOLING

5) PASSIVE: SOLAR GREENHOUSE

6) ACTIVE: THERMOSIPHON HOT WATER HEATER

7) HYBRID: SPACE HEATING AND COOLING, COLLECTORS AND WATERWALL


VILLAGE HOMES - A SOLAR SUBDIVISION

8) ACTIVE: SPACEHEATING AND HOT WATER

9) ACTIVE: PUMPED HOT WATER

10) ACTIVE: DIRECT GAIN HEATING AND CONVECTIVE COOLING

11) ACTIVE: PUMPED HOT WATER

12) ACTIVE: THERMOSIPHON HOT WATER

13) ACTIVE: THERMOSIPHON HOT WATER

14) PASSIVE: DIRECT GAIN HEATING AND CONVECTIVE COOLING

## 7.0 SOLAR ACCESS GLOSSARY

| | | |
|---|---|---|
| Active solar systems | - | Solar systems using external power to operate pumps or blowers to transfer energy from a collector to storage and then on to the end use. Active solar systems are practical for heating only, and may become practical for cooling when costs are reduced considerably. |
| Altitude | - | The angle that describes the height of the sun above the horizon. |
| Ambient temperature | - | Outside air temperature. |
| Azimuth | - | The angle that describes the location of the sun relative to true south. |
| Breadbox water heaters | - | A solar heating system that combines collector and storage, basically black tanks in an insulated box with a south window. |
| Collector | - | Any of a wide variety of devices used to collect the sun's energy for heating or dissipate heat for natural cooling. |
| Cool night sky and cool north sky | - | The sky temperature at night, and to the north in the day, may be 25-30°F below ambient. |
| Climate | - | A description of average weather based on records from many years. |
| Deciduous vegetation | - | Vegetation that drops all of its leaves during the fall. |
| Diffuse solar radiation | - | Solar energy scattered by water, dust, and gas molecules in the atmosphere before eventually reaching the surface. |
| Direct solar radiation | - | Solar energy that comes straight from the sun. |
| Envelope zoning | - | Zoning that includes allowable length, width and height. |
| Evergreen vegetation | - | Vegetation that retains some or all of its leaves throughout the year. (This is more strict than evergreen in the botanical sense.) |
| Natural cooling | - | Cooling using a passive solar system can use any one of five basic natural cooling techniques--solar control, convection, conduction, evaporation, and radiation to the cool night or north sky. |

| | |
|---|---|
| Passive solar systems | - Solar systems that operate without external sources of power. Usually collector/structure/distribution are integrated. Passive solar systems provide economic heating as well as natural cooling. |
| Reflected radiation | - Solar radiation received after reflection from a special reflector, ground, water surface or snow. |
| Setback | - A distance from lot edge in which certain types of buildings are prohibited or restricted. |
| Skyvault | - The sky from horizon to horizon. |
| Skyview | - The view of the skyvault for a particular site and collector orientation, typically only that portion where the sun is located but may include almost the full skyvault for natural cooling. |
| Solar access | - Provision of needed skyviews for successful operation of solar systems. |
| Solar rights | - The legal protection of needed skyviews for the successful operation of solar systems. |
| Solar tempered | - A standard house properly oriented for solar heating and natural cooling. |
| Use pattern | - The use of the solar system throughout the day, season or year. |
| Zenith | - The point on the skyvault directly above the observer. |

# 8.0 APPENDICES

## 8.1 APPENDIX 1 - FURTHER READINGS

### PLANNING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## 8.2 APPENDIX 2 - SUN PATH

An understanding of how the sun moves through the year is essential for proper orientation and solar rights. Two terms are used to describe the position of the sun. The azimuth of the sun is the angle of the sun from true south (not magnetic south). The altitude of the sun describes the elevation of the sun above the earth's surface.

The winter sun may only reach 38° altitude in Southern California or 30° altitude in Northern California, making solar access difficult to protect. There may be less severe but no fewer problems with solar access to the summer sun. For more detailed information on solar position throughout the year, refer to the ASHRAE Handbook of Fundamentals or other architectural or engineering references.